CZ2003: Tutorial 7

Due on March 9, 2021 at 10:30am

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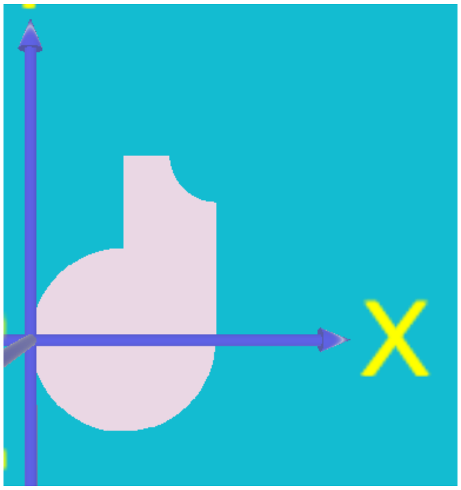
Problem 1

Consider a 2D object defined implicitly by
$max(1-(x-1)^2-y^2, min(min(x-1, 2-x, y, 2-y), -(0.25-(x-2)^2-(y-2)^2))) \geq 0$

i Draw a diagram to show the hierarchical representation of the object.

ii Find the minimum axis-aligned bounding rectangle of the object.



Solution
Part i:
We can see that the 2D object is made up of 3 main components:

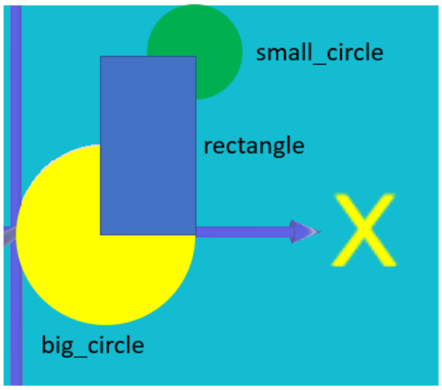
1. A Big Circle, defined by $1-(x-1)^2-y^2 \geq 0$
2. A Rectangle, defined by $min(x-1, 2-x, y, 2-y) \geq 0$, which is made of

   $x-1 \geq 0$

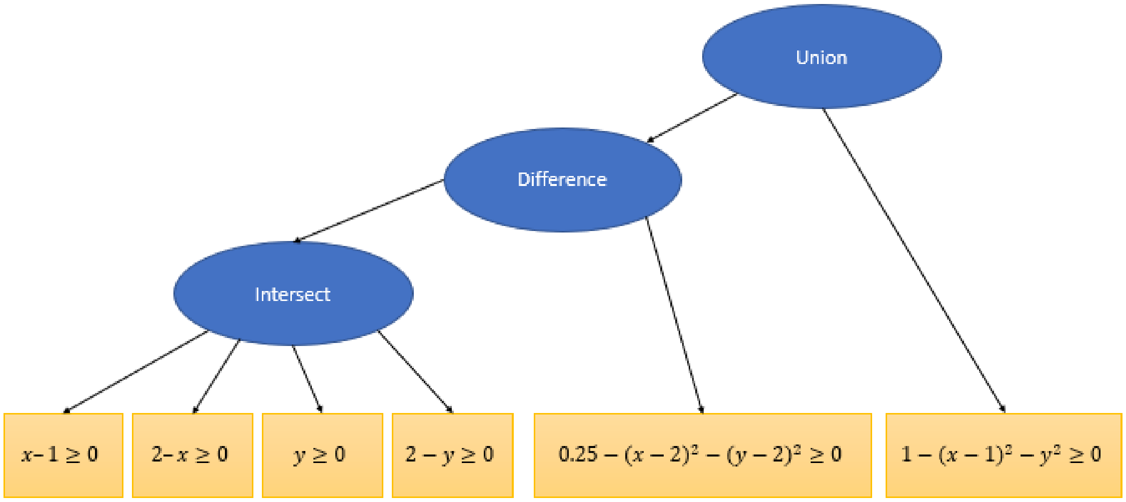
   $2-x \geq 0$

   $y \geq 0$

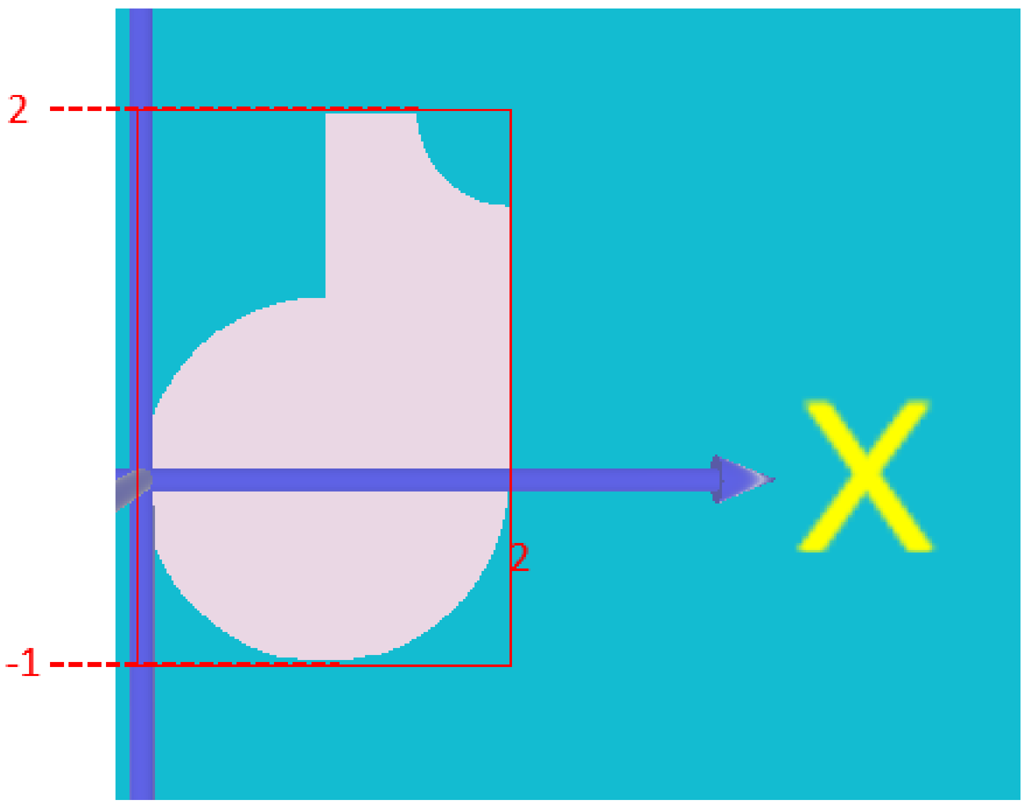
   $2-y \geq 0$
3. A Small Circle, defined by $0.25-(x-2)^2-(y-2)^2 \geq 0$ (subtracted from the rectangle)



Therefore, a DAG can be used as the hierarchical representation as shown below:



Part ii:
The minimum axis-aligned bounding rectangle of the object is shown below:



Therefore, the bounding box **size** can be given as $(2, 3)$, with the bounding box **location** being $(1, 0.5)$

Problem 2

With reference fo Figure Q2, suggest a database organization for a virtual city containing a factory, an office, houses and trees. The organization should be hierarchical and does not have duplication in the primitive level.

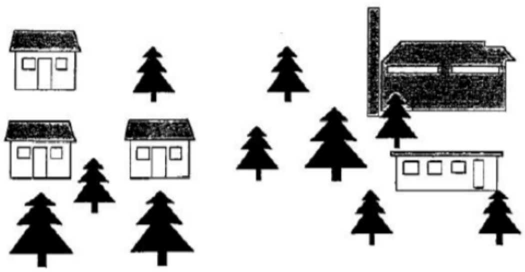
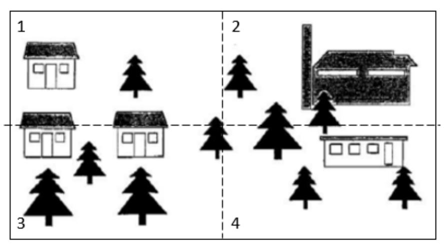


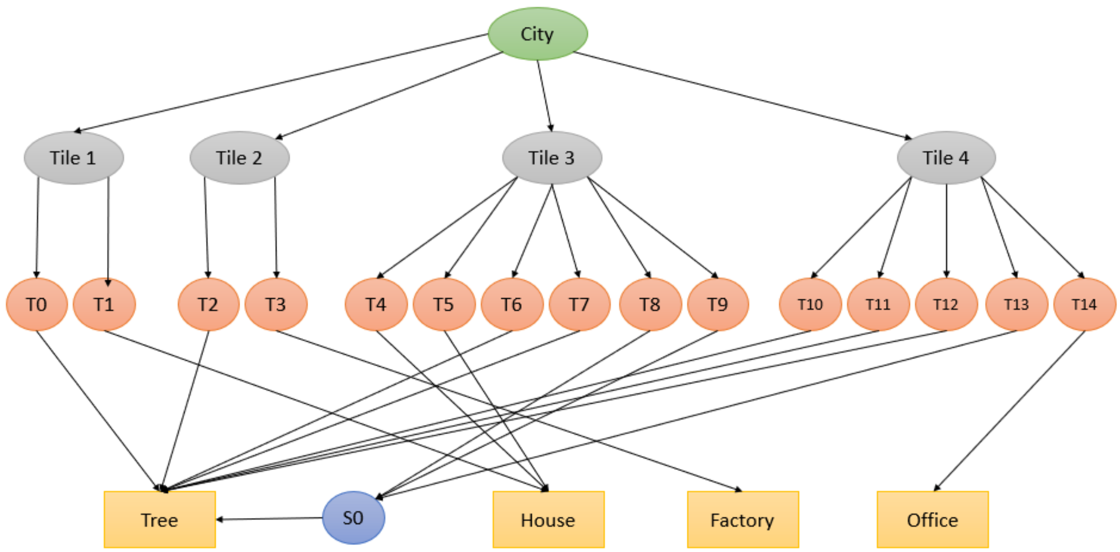
Figure Q2

Solution

For this question, spacially-partitioned organization is used for efficient rendering. The virtual city is divided into 4 tiles as shown below:



Therefore, the organization can be shown with the following DAG:



Problem 3

Propose how to implement parametrically a continuous level-of-detail for an ellipsoid defined by parametric equations

$$x = 1 + cos\phi cos\theta \quad -\pi/2 \leq \phi \leq \pi/2$$

$$y = 2 + 2cos\phi cos\theta \quad 0 \leq \theta \leq 2\pi$$

$$z = 3 + 3sin\phi$$

Solution
A continuous LOD can be implemented by sampling ϕ and θ based on the distance from the observer to the ellipsoid.
The sampling for ϕ can be defined as:

$$\phi = -\frac{\pi}{2} + \delta \cdot i$$

The sampling for θ can be defined as

$$\theta = \delta \cdot j$$

where δ is a function of distance, $\delta = \delta(d)$.

For instance, it can be defined as:

$$\delta(d) = c * d + \epsilon$$

Where c and ϵ are two constants

Problem 4

With reference to Figure Q4, a 3D object is defined implicitly by:

$$min(z, min(1 - z, 1 - \frac{x^2}{4} - y^2)) \geq 0$$

i Find the minimum axis-aligned bounding volume of the object.

ii Propose reasonable resolutions for visualizing this object.

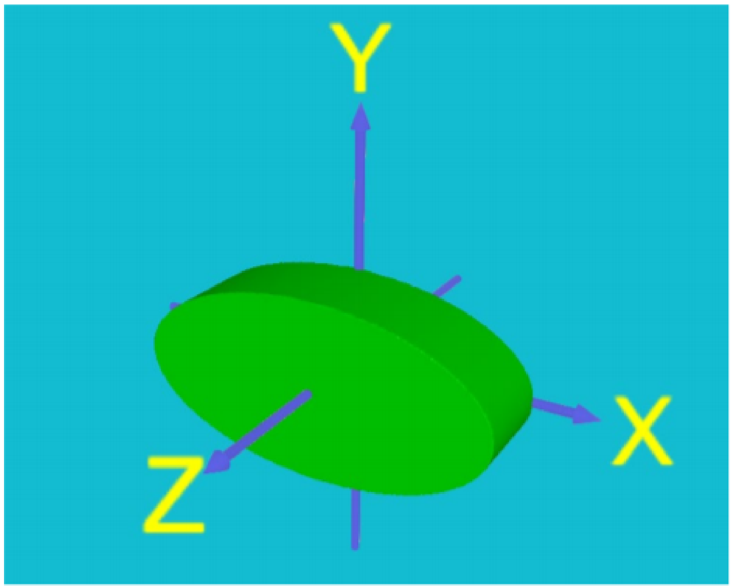
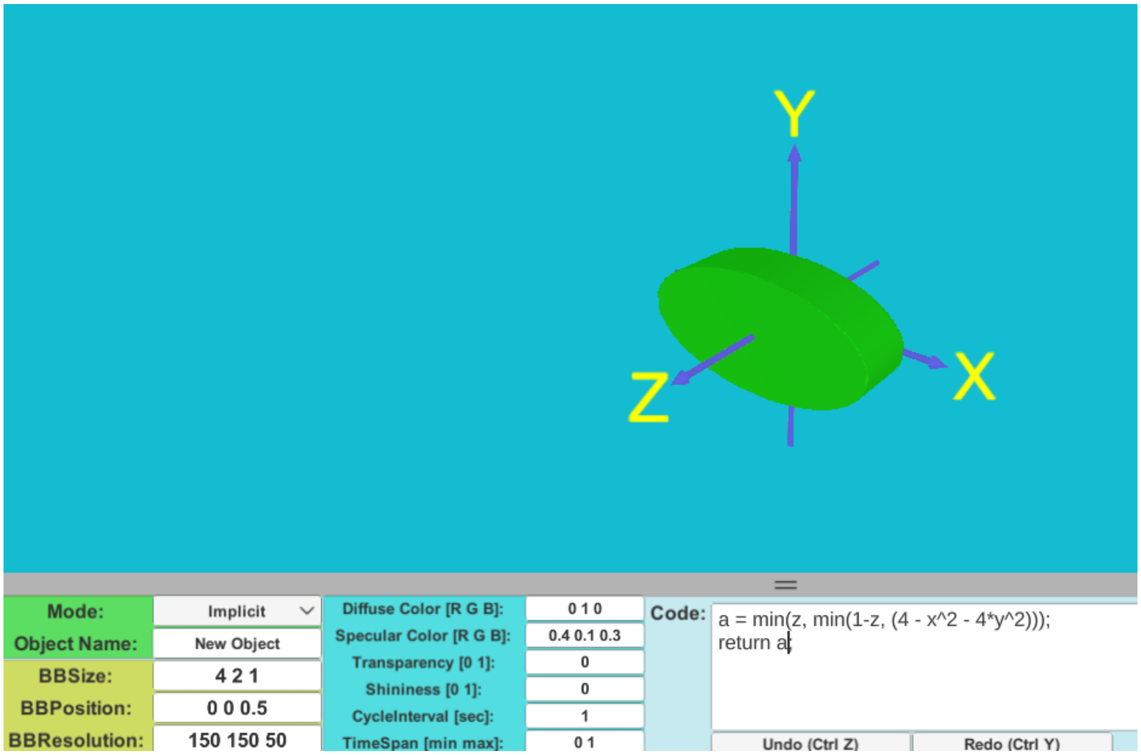


Figure Q4

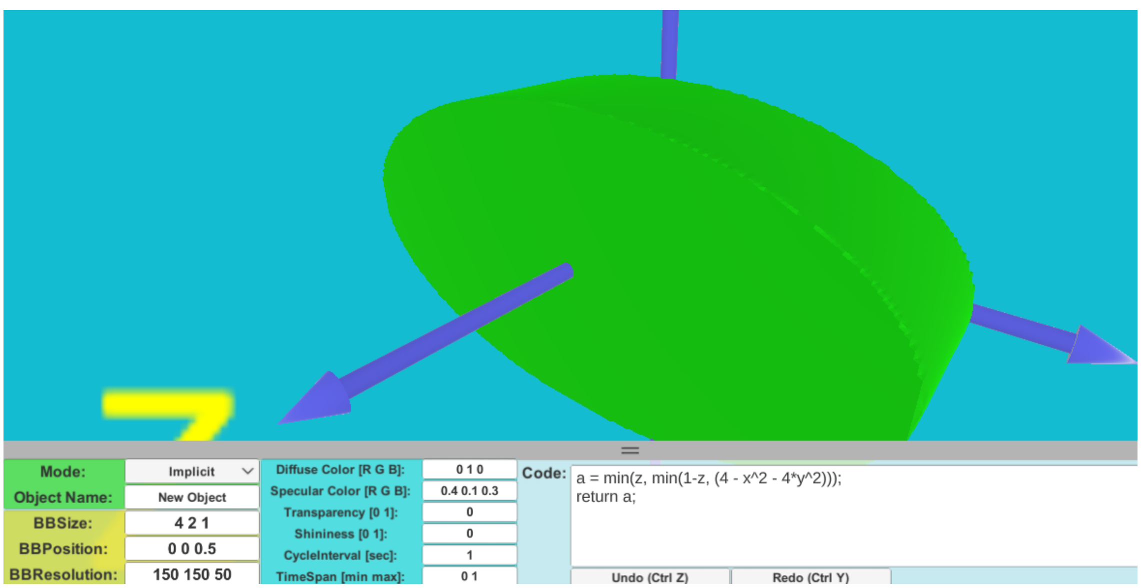
Solution
Part i:
First, we find the limits of the 3D object in XYZ:
Max X: +2
Min X: -2
Max Y: +1
Min Y: -1
Max Z: 1
Min Z: 0
Therefore, Bounding Box Size can be obtained with the following:
$BBSize = (2 - (-2) \;\; 1 - (-1) \;\; 1 - 0) = (\mathbf{4} \;\; \mathbf{2} \;\; \mathbf{1})$
Bounding Box Position can be obtained with the following:
$BBPosition = ((2 + (-2))/2 \;\; (1 + (-1))/2 \;\; (1 + 0)/2) = (\mathbf{0} \;\; \mathbf{0} \;\; \mathbf{0.5})$

Part ii:

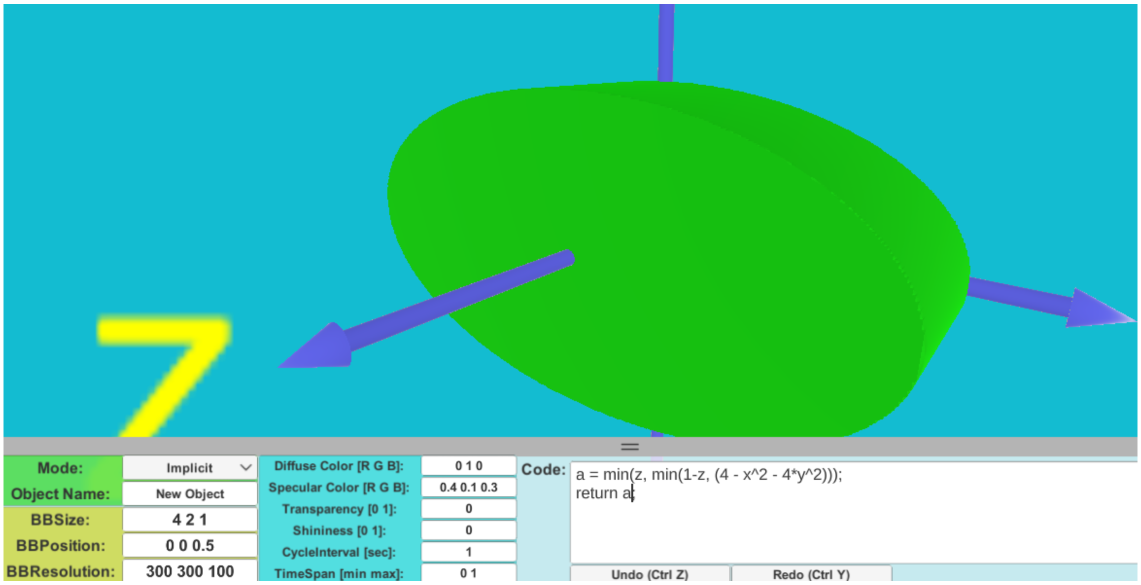
To replicate the figure with the distance shown in Q4, a sampling resolution of (**150 150 50**) is reasonable for visualizing it:



However, when zoomed in, the interpolations can be seen and the edges of the object appear jagged. Therefore a higher sampling resolution would be required:



Therefore, the resolution of (**300 300 100**) was used, which resulted in the edges being rendered correctly.



However, it is worth noting that this also negatively impacted the rendering time due to to increased amount of rendering points.